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Quebec Region | Science Response 2018/025

POTENTIAL EFFECTS OF THE CONSTRUCTION OF MARINE TERMINALS IN THE SAGUENAY FJORD ON THE ST. LAWRENCE BELUGA WHALE AND ITS HABITAT

Context

The construction of two new marine terminals is planned in the upstream section of the Saguenay Fjord. There are plans to build a terminal on the north shore, in the Sainte-Rose-du-Nord area (Saguenay Port Authority project), and a second, near the Grande-Anse marine terminal in the Saguenay borough of La Baie (Énergie Saguenay project). Once in operation, these two terminals would increase the volume of marine traffic on the Saguenay by 300 vessels, from 225 vessels per year (in 2016) to 525 per year. By 2030, traffic at the Grande-Anse and Bagotville wharves is expected to increase by 110 vessels. The total of 635 vessels, or 1,270 transits per year, will produce a 2.8-fold increase in the number of vessels navigating the Saguenay.

The two new terminals are to be constructed at the northern edge of the St. Lawrence Estuary beluga's range in the Saguenay. To reach the new terminals, vessels will have to cross very important beluga habitat, including critical habitat as defined in the recovery strategy.

This Science Response Report results from the Science Response Process from the Regional Ecosystems Management Branch (REMB) to the Regional Science Branch (RSB) to assess the potential effects of marine terminal construction projects in the Saguenay Fjord on the St. Lawrence Estuary beluga and its habitat. The REMB's specific questions are:

Question 1. Indicate whether the increase in marine traffic resulting from the project(s) may (define the risk level as "none," "low," or "high"):

(a) Harm belugas (individuals)
(b) Where applicable, jeopardize the survival or recovery of the beluga population
(c) If applicable, specify: Which function of the life cycle will be affected; how it will be affected; and during which period of the year. Please indicate whether any areas are at greater risk.

Question 2. No mitigation measures that might be implemented by the proponent were presented in the impact study, apart from participation in the Working Group on Marine Traffic and Protection of Marine Mammals in the Gulf of St. Lawrence committee (G2T3M) of the St. Lawrence Action Plan's Navigation Coordination Committee. Please indicate, where applicable, the mitigation measures that would avoid:

(a) Jeopardizing the survival or recovery of the beluga population
(b) Harming belugas (individuals).
(c) Please indicate the extent to which these mitigation measures would reduce the level of risk in (a) and (b) (define the risk level as "none," "low," or "high").

Question 3. Are other marine mammal species in the Saguenay Fjord and the St. Lawrence Estuary (SLE) likely to be affected by the increase in marine traffic caused by the project(s)?

(a) If so, which species?
(b) Do the Beluga Whale risk assessments and mitigation measures apply to those species? If not, what would the effects and appropriate mitigation measures be?

This Science Response Report results from the Science Response Process of the January 2018 on the potential effects of the construction of terminals in the Saguenay Fjord on the St. Lawrence Beluga whale and its habitat.

Background

Current status of the SLE Beluga population

There are at least seven Beluga (*Delphinapterus leucas*) populations in Canada. The SLE population is at the southernmost edge of this Arctic species' circumpolar range. Decimated by over-hunting, this population was, until recently, considered threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). However, abnormal mortalities among young Beluga Whales since 2008 led to a reassessment of the status of this population in 2013 (DFO 2014) and a reassessment by COSEWIC of the status of this population, which has since been considered endangered (COSEWIC 2014). There were about 900 individuals in the SLE population when the last assessment was conducted in 2012 (DFO 2014).

The SLE Beluga population is listed in Schedule 1 of the *Species at Risk Act*. Its critical habitat was identified and recently legally protected. It is the area occupied by females accompanied by calves and juveniles from June to October (DFO 2012) (Canada-Gazette 2016) (Figure 1). This area includes the upstream portion of the Saguenay Fjord from its mouth to Baie Sainte-Marguerite, the whole middle estuary between Île-aux-Coudres and the mouth of the Saguenay Fjord, and the southern waters of the lower estuary extending to the east off the coast of Saint-Fabien-sur-Mer. The sections and mouth of the Saguenay Fjord, which are covered by this request for science advice, are therefore part of the SLE Beluga Whale's designated critical habitat.

The population's long-term recovery objective is 7,070 individuals.(DFO 2012). However, a recent sustainability analysis of this population found that this goal is probably unachievable in the context of global warming, even considering the most optimistic management scenarios of key threats to recovery (in no particular order) noise/disturbance, persistent organochlorine pollutants and reduced food availability (Williams et al. 2017).

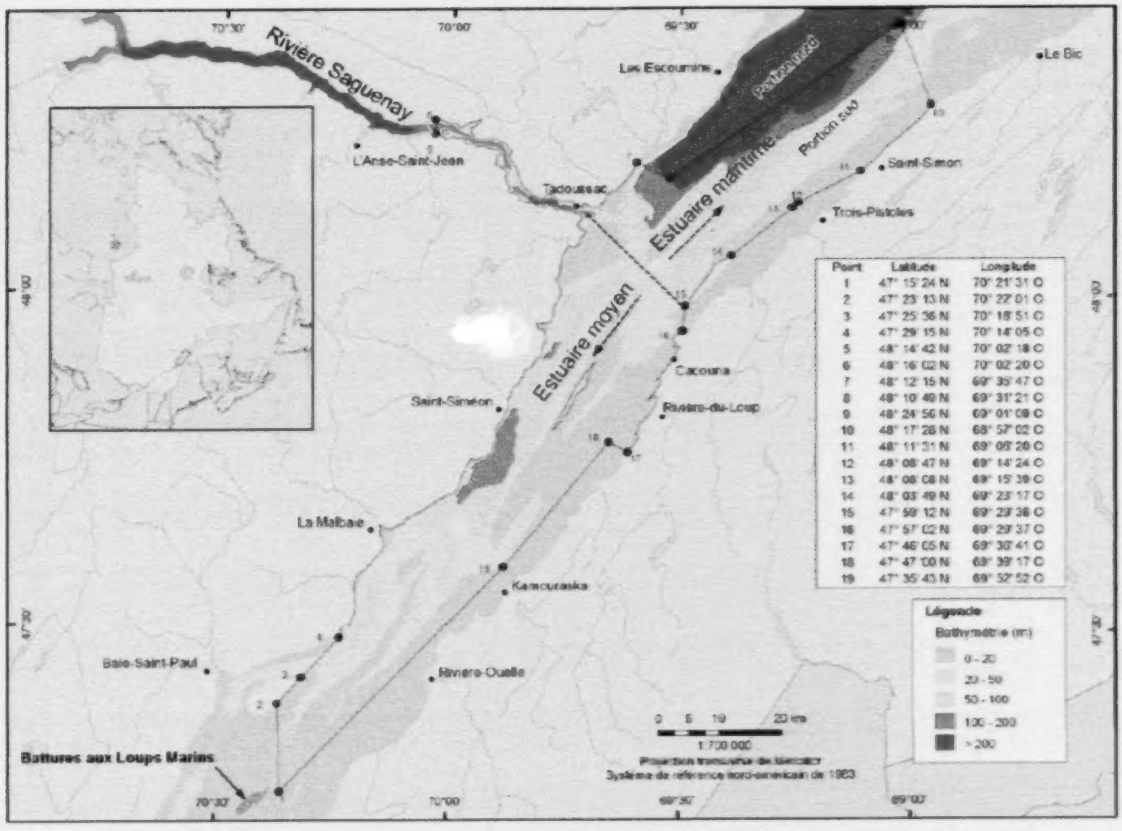
Rivière Saguenay
L'Anse-Saint-Jean
Les Escoumins
Le Bic
Tadoussac
Estuaire maritime
Portion sud
Saint-Simon
Trois-Pistoles
Estuaire moyen
Cacouna
Saint-Siméon
Rivière-du-Loup
La Malbaie
Kamouraska
Baie-Saint-Paul
Rivière-Ouelle
Battures aux Loups Marins
Port Latitude Longitude
1 47° 15' 24 N 70° 21' 31 O
2 47° 23' 13 N 70° 27' 01 O
3 47° 25' 36 N 70° 18' 51 O
4 47° 29' 15 N 70° 14' 05 O
5 48° 14' 42 N 70° 02' 18 O
6 48° 16' 02 N 70° 02' 20 O
7 48° 12' 15 N 69° 35' 47 O
8 48° 10' 40 N 69° 31' 21 O
9 48° 24' 56 N 69° 01' 09 O
10 48° 17' 28 N 68° 57' 02 O
11 48° 11' 31 N 69° 05' 26 O
12 48° 08' 47 N 69° 14' 24 O
13 48° 08' 08 N 69° 15' 39 O
14 48° 03' 49 N 69° 23' 17 O
15 47° 59' 12 N 69° 29' 36 O
16 47° 57' 02 N 69° 29' 37 O
17 47° 46' 05 N 69° 30' 41 O
18 47° 47' 00 N 68° 39' 17 O
19 47° 35' 43 N 69° 52' 52 O
Légende
Bathymétrie (m)
0 - 20
20 - 50
50 - 100
100 - 200
> 200
0 5 10 20 km
1:700 000
Projection transverse de Mercator
Système de référence nord-américain de 1983

Figure 1. Essential St. Lawrence Beluga Whale habitat outlined by the red polygon. Taken from the St. Lawrence Beluga Recovery Plan (DFO 2012).

SLE Beluga range and habitat use

The SLE Beluga's range is about 65% of what it was historically, and it is one of the smallest reported for this species (Mosnier et al. 2010). Although it is based in the SLE, its range varies by season. From June to October, high-density Beluga Whale areas include a variety of areas used recurrently throughout the Saguenay Fjord, the whole upper estuary and the upstream third of the lower estuary, along both the north and south shores (Lemieux Lefebvre et al. 2012, Mosnier et al. 2016). Surveys conducted in August and early September over the years support the idea that, in summer, the population is concentrated in the St. Lawrence estuary, from Batture-aux-Loups-Marins to Rimouski and up to Baie Sainte-Marguerite in the Saguenay Fjord (Figure 1) (Michaud 1993, Lawson and Gosselin 2009, Gosselin et al. 2017).

However, current available data cannot be used to perform a quantitative assessment of changes in the range of the St. Lawrence Beluga Whale population throughout the year. Existing data for periods other than June to October suggest that the Beluga range extends to the lower estuary and the northwestern Gulf (Sears and Williamson 1982, Boivin and INESL 1990, Michaud and Chadenet 1990). The timing of these movements and the percentage of the population exiting the SLE toward the east are unknown. In spring, the Beluga Whale range is at its maximum, extending at least from the Île-aux-Coudres area in the upper estuary to the northwestern Gulf of St. Lawrence, including the mouth of the Saguenay (Mosnier et al. 2010; Conversano et al. 2017; J.-F. Gosselin, Fisheries and Oceans Canada, unpublished multi-year

seasonal data; Y. Simard, Fisheries and Oceans Canada, unpublished multi-year acoustic data). Observations in the Marine Park at the mouth of the Saguenay indicated that the number of whales sighted in spring and summer were relatively similar but a decrease in sightings and average number of individuals was noted in October and November (Conversano et al. 2017). However, information on the number of Beluga Whales in the Saguenay outside the June to October period is still fragmented.

SLE Beluga Whales calve from June to September. Although the functions of the various high-use areas are not well defined, these areas are likely to be used for a variety of activities including feeding, recreation, socialization and juvenile rearing. Since Beluga Whales, regardless of population, have never been observed calving in the wild, their calving areas cannot be accurately defined. Nevertheless, since critical habitat is the summer range of females with juveniles and calves, and calving occurs during this period, we can assume it occurs in some of the high-use areas (Mosnier et al. 2010, Mosnier et al. 2016).

Use of the Saguenay Fjord by the SLE Beluga

Saguenay-St. Lawrence Marine Park performed routine summer monitoring from 2003 at 2016 at two sites frequently used by the Beluga Whale: Pointe Noire at the mouth of the Saguenay and Baie Sainte-Marguerite in the Saguenay Fjord. The 2003 to 2016 results indicated that the Beluga Whales' use of Baie Sainte-Marguerite increased from June to July and that levels observed in July and August were maintained at least until September (Conversano et al. 2017, Figure 14). Based on the July and August data, it is estimated that Beluga Whales use Baie Sainte-Marguerite 66% of the days and 44% of the total observation time (6 a.m. to 8 p.m.) (Conversano et al. 2017). Given the distance between the mouth of the Saguenay and Baie Sainte-Marguerite (about 12 nautical miles) and the Beluga Whale's average speed when travelling (about 3 to 3.5 knots), it is estimated that it takes a Beluga Whale seven to eight hours to make a round trip to Baie Sainte-Marguerite and exit the Saguenay. This does not include the average time spent in Baie Sainte-Marguerite or other habitats in the fjord.

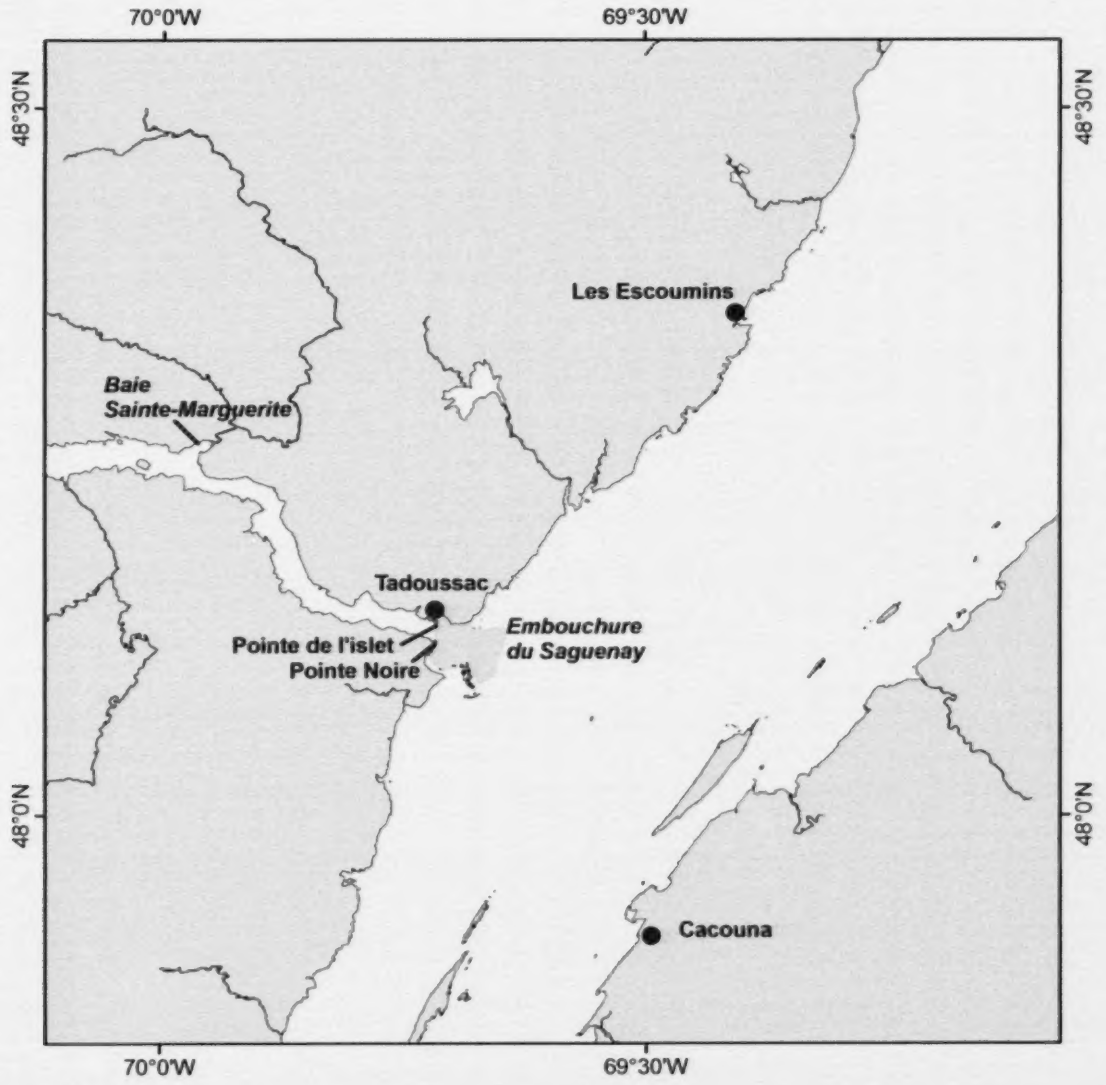

Figure 2: Map of the St. Lawrence estuary and Saguenay Fjord showing the area considered to be the mouth of the Saguenay downstream from Tadoussac (in blue). This area is used in the analysis of aerial observations using the kernel method.

Observations made in the Pointe Noire area at the mouth of the Saguenay Fjord from May to November revealed an average use of 86% of days and 48% of total observation time from 6 a.m. to 8 p.m. (Conversano et al. 2017, Tableau 3, Figure 14).

The average size of the pods (number of Individuals detected in the study area) observed in July and August in the relatively small Baie Sainte-Marguerite area, ranged from 5.2 to 23.0 individuals, with maximum values fluctuating between 24 and 105 individuals, for an average school size of 11.8 ± 4.2 individuals (Conversano et al. 2017, Tables 4 and 6). However, the average size of schools in the Pointe Noire area at the mouth of the fjord, which the whales have to cross to reach Baie Sainte-Marguerite, was smaller in this area, 5.9 ± 0.8 individuals. A

greater number of Beluga Whales is likely to be found in the mouth of the Saguenay Fjord than in Baie Sainte-Marguerite Bay, because individuals in the mouth area of the fjord, but downstream and upstream from the 3-km observation area around the observation point in Pointe Noire, are missed or do not necessarily swim all the way up to Baie Sainte-Marguerite.

The average number of individuals detected varies according to the time of day between 6 a.m. and 8 p.m., with lower numbers after 3 p.m. at the mouth of the Saguenay and higher numbers between 1 p.m. and 6 p.m. in Baie Sainte-Marguerite. The number of individuals increases with the flood and decreases with ebb tide at the mouth of the Saguenay, and the opposite is observed in Baie Sainte-Marguerite. Most of the pods at the mouth of the Saguenay and Baie Sainte-Marguerite are composed of young and adults (white individuals), some of whom have calves of the year. The statistics for July and August in Baie Sainte-Marguerite indicate that 91% of the pods include juveniles and that 49% of those in the Baie include calves (Conversano et al. 2017).

Based on 44 photographic and visual aerial surveys performed from mid-August to early September from 1988 to 2014 to estimate beluga abundance in the SLE and the Saguenay (Gosselin et al. 2017), it is estimated that on average 1.7% (standard deviation = 1.3%, range: 0.3 – 4.2%, n = 44 surveys) of the population was detected in the Saguenay Fjord upstream from Tadoussac (from Pointe Noire and Pointe de L'islet). By combining the kernel method with the Saguenay surveys, it is estimated that on average 0.5% (standard deviation = 0.8%, range: 0 – 2.5%, n = 35 surveys) of the population was detected at the mouth of the Saguenay downstream from Tadoussac, in the channel between Batture aux Alouettes and Batture aux Vaches downstream from Tadoussac up to the last sill before the head of the Laurentian Channel (data taken from Gosselin et al. 2017, Mosnier et al. 2016). When these values are added, the average percentage of the SLE population observed throughout the fjord, including its mouth, is 2.2% (standard deviation = 1.4%, range: 0.3 – 4.4%). Assuming a population of about 900 individuals (Mosnier et al. 2015), we obtain an estimate of 19.8 individuals on average in the mouth and fjord of the Saguenay in August. This value is relatively close to the total (17.7) of the surveys conducted in Baie Sainte-Marguerite (11.8 ± 4.2 individuals) and at the mouth of the fjord (5.9 ± 0.8 individuals) for the period from 2003 to 2016 (Conversano et al. 2017, Tables 3 and 4).

Function of the Saguenay Fjord for the SLE Beluga

The Beluga Whale must cross the Saguenay Fjord and its mouth to reach Baie Sainte-Marguerite. The whales likely feed in the mouth and certain areas of the Saguenay. What attracts the Beluga Whale to the Saguenay Fjord and Baie Sainte-Marguerite, whose waters are brackish and relatively fresh, remains uncertain but could include feeding, socialization, juvenile rearing and rest (reviewed in Mosnier et al. 2010). Its use for calving cannot be ruled out.

Other species of marine mammals in the Saguenay Fjord

The Saguenay Fjord and its mouth are also used by other species of marine mammals, including the Minke Whale (*Balaenoptera acutorostrata*) and Harbour Seal (*Phoca vitulina*), which have several haulout sites in the area (Robillard et al. 2005). Grey Seal herds (*Halichoerus grypus*) are also observed in the mouth on a regular basis, while whales such as the Blue Whale (*Balaenoptera musculus*), Fin Whale (*Balaenoptera physalus*) and Humpback Whale (*Megaptera novaeangliae*) are occasionally reported off the mouth (Kuker 2005, Conversano 2013; V. Lesage, Fisheries and Oceans Canada, pers. obs.). In winter, Harp Seal herds (*Pagophylus groenlandicus*) are also observed off the mouth on a regular basis and in the Escoumins area before (December to February) and after (March to April) calving (Sergeant 1991).

Scope and mechanisms of the effects of marine traffic

The effects of marine traffic on aquatic ecosystems and their biological resources can be traced through several pathways (see list in DFO 2015). These pathways include the risks of chemical contamination, spills of hazardous products, collisions and alteration of the underwater sound environment. The underwater sound environment is altered in large areas around a vessel in transit (e.g. Aulanier et al. 2016a). This is likely to affect marine mammals in particular because they use sounds extensively to perform vital functions such as perceiving their environment, navigating, communicating and using echolocation to hunt their prey (e.g. Weilgart 2007, Gomez et al. 2016).

Collisions

There is a risk of collision when ships cross areas used by marine mammals. These events and their severity have been documented in some parts of the world (van Waerebeek et al. 2007, van Waerebeek and Leaper 2008, Wiley et al. 2011, Silber et al. 2012). However, the number of collisions and their impact on marine mammal populations are underestimated since only a small percentage of collisions are detected or reported (Laist et al. 2001, Jensen and Silber 2003, Panigada et al. 2006, van Waerebeek et al. 2007, van Waerebeek and Leaper 2008). A study of 14 whale species in the northern Gulf of Mexico suggested that, on average, only 2% of natural or accidental marine mammal mortalities at sea (resulting from collisions or other causes) are recorded (Williams et al. 2011).

Collision reports suggest that vulnerability to collision risk varies by species. The main whale species affected by collisions are the Fin Whale, Humpback Whale, Right Whale (*Eubalaena glacialis and E. australis*) and Sperm Whale (*Physeter macrocephalus)* (Laist et al. 2001, Jensen and Silber 2003, van Waerebeek et al. 2007, van Waerebeek and Leaper 2008). Compared to larger whales, small toothed whales, such as belugas and dolphins, are likely to be less vulnerable to collisions with larger vessels because of their greater ability to manoeuvre, exceptional hearing, echolocation capacity and social behaviour (forming groups of individuals to increase detection and avoidance capabilities—assuming avoidance is not impaired by local conditions such as ice) (Au and Perryman 1982, Wursig et al. 1998). Nevertheless, collisions involving small toothed whales such as the Beluga Whale, Pilot Whale (*Globicephala melonae*), Killer Whale (*Orcinus orca*) and beaked whales (*Mesoplodon* sp.) are listed in the databases (Rossiter 2006, van Waerebeek et al. 2007; G. Silber, Office of Protected Resources, unpubl. MS), indicating a certain level of vulnerability to collisions.

Vessel speed is a determining factor in the severity of collisions (Vanderlaan and Taggart 2007, Beck et al. 2013, Conn and Silber 2013) (Figure 3). The probability that a large whale struck by a ship travelling at a speed varying from 8.6 to 15 knots will sustain a lethal injury (Pr_{lethal}) increases from 0.21 or 0.55 to 0.79 depending on the prediction model used (Vanderlaan and Taggart 2007, Conn and Silber 2013). Beyond 15 knots, the probability of a fatal collision approaches 1 in both models, indicating that the animal is almost sure to die. The Pr_{lethal} value drops below 0.5 at speeds varying between 9 and 11.8 knots depending on the models, and this proportion becomes very variable at lower speeds. If this relationship is valid for a variety of marine mammals, then collisions with cargo ships, tankers or container ships transiting at their usual speed are likely to be fatal.

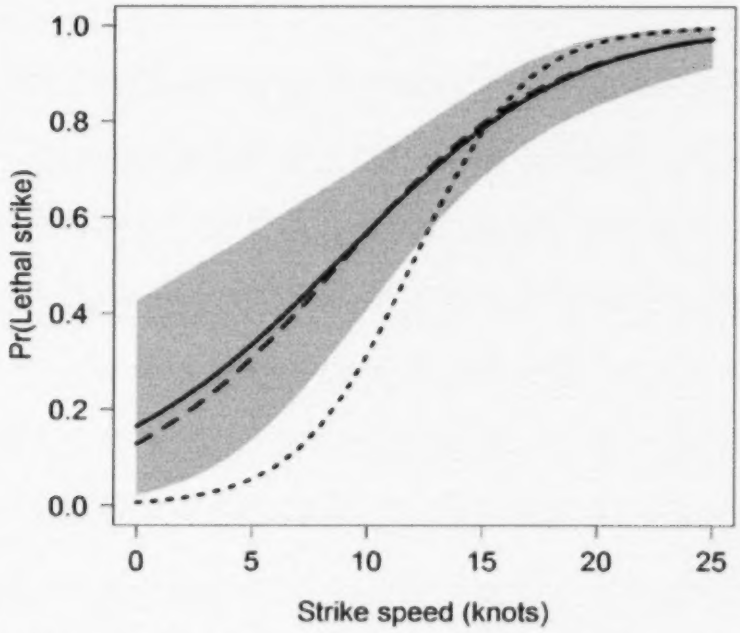

Figure 3: Taken from Conn and Silber (2013). According to reports available worldwide, the risk of collision for large whales increases with vessel speed. The dotted and long-line curves represent predictions by Vanderlaan and Taggart (2007) and Conn and Silber (2013) based on a logistic regression model. The solid line represents the Bayesian posterior mean estimate by Conn and Silber (2013). The shaded area represents the 95% credibility interval in the Bayesian model.

Spills

Marine traffic can also affect marine mammals by increasing the risk of spills. The effects of spills on the health of marine mammals have been amply documented (Loughlin 1994) in the special 2017 issue (Volume 33) of the Endangered Species Research scientific journal for the results of several marine traffic studies.

Noise

The Beluga is a toothed whale known to use sounds extensively to communicate (Schevill and Lawrence 1949, Sjare and Smith 1986, Faucher 1988, Simard et al. 2010b, Le Bot et al. 2016) and probe the environment by echolocation using ultrasonic biosonar pulses (Au 1993, Au and Hastings 2008, Roy et al. 2010). Its audiogram shows that it can also hear sounds over a wide frequency band, from 100 Hz to over 100 kHz, and its hearing is most sensitive between 20 kHz and 80 kHz (Finneran et al. 2005, Erbe et al. 2016). Sound radiated into the environment by marine traffic straddles the frequency bands that the Beluga can hear and uses for communication and echolocation (Gervaise et al. 2012, Erbe et al. 2016).

The effects of noise on mammals include damage to the inner ear causing temporary or permanent hearing loss (cf. Southall et al. 2007), or masked sound perception, communication and echolocation functions (cf. Erbe et al. 2016). Masking is associated with the shipping noise, while inner ear damages are related to strong noise impulses. Thresholds for the onset of hearing loss from non-impulsive noise in whales like the Beluga Whale that are sensitive to mid-frequency sounds are cumulative 24-hour exposure levels in excess of 178 dB_{MF} re 1 μPa^2s for temporary hearing loss and 198 dB_{MF} re 1 μPa^2s for permanent hearing loss (NOAA 2016).

These sound levels are never reached in St. Lawrence Beluga Whale habitat, even in the peak marine traffic area at the mouth of the fjord where ferries run continuously and the ecotourism fleet operates during the day, according to continuous measurements taken for more than one month at this location by Gervaise et al. (2012).

However, masking (Erbe et al. 2016) and disturbances are possible (cf. Gomez et al. 2016) when ships transit through areas used by the Beluga Whale. The frequency and duration of these changes in ambient noise levels are indicators of the potential for disturbance. Noise can affect the Beluga Whale in two ways: by reducing the duration of quieter periods between two noise events and by chronically increasing ambient noise levels as a result of underwater shipping noise that travels long distances and because of the interval between two ship transits. Noise can therefore spatially and temporally reduce the animals' acoustic space, which can force the animals to use their vital functions during quieter periods or limit them to smaller areas.

Currently, the cumulative impacts on individuals in the SLE cannot be quantified in a variety of areas, which makes it difficult to estimate the percentage of the Beluga Whale population that may be affected by the increase in traffic. However, estimates of potential Beluga Whale disturbance time were calculated based on short-term acoustic measurements performed in 2016 by DFO in the Saguenay Fjord during merchant ship transits (Y. Simard, Fisheries and Oceans Canada, unpublished data) for a period of over one month using an acoustic network at the mouth of the fjord in 2009 (Gervaise et al. 2012), and observation of marine traffic along the St. Lawrence Seaway in 2012 to 2013 (Simard et al. 2016). The two acoustic functions considered were communication (0.2 kHz to 10 kHz frequency band) and echolocation (>10 kHz). The time during which the acoustic footprint was clearly distinguishable from ambient noise during a merchant ship transit was estimated at 34 minutes for the communication band and 14 minutes for the echolocation band. In the mouth segment, where the ferry schedule varies throughout the day, the crossing time is 7.5 minutes (Gervaise et al. 2012), and ferry transits equally affect the two frequency bands used by the Beluga Whale.

In 2016, 225 merchant ships transited along the fjord (i.e. 450 transits or trips) (WSP 2017a, p. 229). The number of additional ships for the north terminal multi-user wharf was revised to 140 (*Ibid.*). The figure for the GNL Québec wharf is 160 additional ships (*Ibid.*). By 2030, the increase in traffic expected at the Grande-Anse and Bagotville wharves will add another 110 ships (*Ibid.*). A total of 635 ships (1,270 transits) are expected to transit in the fjord in 2030. Current shipping traffic in the St. Lawrence Estuary is approximately 6,000 transits per year.

Based on this information, we can estimate the maximum percentage (%) of the time per year when noise from merchant ships may affect communication and echolocation functions, meaning the noise from the ship exceeds ambient noise levels prior to the ship's transit (Tables 1 to 3). This is a conservative estimate in the case where thresholds for the onset and exact nature of the effects on Beluga Whale behaviour have yet to be specified.

Table 1. Estimate of the percentage (%) of the time that communication and echolocation functions may be affected by current and projected shipping traffic for 1 year in the section of the fjord upstream from the 5-km mouth. F indicates the rate of increase in marine traffic versus 2016 levels (Saguenay = 225 ships [450 transits], Lower estuary = 3,000 ships [6,000 transits]). Values in parentheses are weighted by the average percentage of the population observed in the fjord (1.7% upstream from the mouth and 0.5% at the mouth).

Function	Duration of the Effect (Min)	Number of Merchant Ships per Year in the Upper Saguenay				
		225 F= 1.0	285 (i.e. +60) F=1.27	365 (i.e. +140) F=1.62	525 (i.e. +300) F=2.33	635 (i.e. +410) F=2.82
Communication	34	2.9% (0.05%)	3.7% (0.06%)	4.7% (0.08%)	6.8% (0.12%)	8.2% (0.14%)
Echolocation	14	1.2% (0.02%)	1.5% (0.03%)	1.9% (0.03%)	2.8% (0.05%)	3.4% (0.05%)

Table 2. Like Table 1, but for the 5-km segment of the mouth affected by current ferry noise.

Function	Duration of the Effect (Min)	Number of Merchant Ships per Year in the Upper Saguenay				
		225 F= 1.0	285 (i.e. +60) F=1.27	365 (i.e. +140) F=1.62	525 (i.e. +300) F=2.33	635 (i.e. +410) F=2.82
Communication	34	45.5% (0.23%)	46.3% (0.23%)	47.3% (0.24%)	49.4% (0.25%)	50.8% (0.25%)
Echolocation	14	43.8% (0.22%)	44.1% (0.22%)	44.5% (0.22%)	45.4% (0.23%)	46.0% (0.23%)

Table 3. Like Table 1, but for the St. Lawrence lower estuary.

Function	Duration of the Effect (Min)	Number of Merchant Ships per Year in the Upper Saguenay				
		225 F= 1.0	285 (i.e. +60) F=1.02	365 (i.e. +140) F=1.05	525 (i.e. +300) F=1.10	635 (i.e. +410) F=1.14
Communication	34	38.8%	39.6%	40.6%	42.7%	44.1%
Echolocation	14	16.0%	16.3%	16.7%	17.6%	18.2%

Marine traffic on the Saguenay varies with the seasons. Quarterly traffic, starting in December, is respectively 19%, 23%, 26% and 32% (WSP 2017a, p. 230). There are no transits on about one third of the days. There are 1 to 2 transits on half of the days. There are 3 to 5 transits on 15% of the days. There are more than 5 transits on less than 1% of the days.(WSP 2017a, p. 231). However, the annual averages estimated in the tables above assume constant year-round traffic.

Analysis and Response

Question 1. Indicate whether the increase in marine traffic resulting from the project(s) may (define the risk level as "none," "low," or "high"):

(a) Harm beluga whales (individuals).

Yes. The risk of collision associated with this increase in the number of transits by large ships travelling on a straight course at their usual speed is considered low for the Beluga Whale. However, this increase in marine traffic is likely to harm Beluga Whales who use the Saguenay Fjord and the St. Lawrence Estuary on a regular basis, because the noise levels to which the

animals are currently exposed will be altered. The increase in noise levels is unlikely to cause temporary or permanent hearing loss. However, the current duration of the silent period for communication and echolocation will be reduced in proportion to the increase in local traffic. In the fjord upstream of the mouth, it is estimated that current marine traffic may potentially affect communications at most, 2.9% of the time. This figure would increase to 8.2% of the time based on the total traffic scenario in 2030. The same estimates for echolocation are 1.2% of the time now, and this figure would increase to 3.4% of the time in 2030. At the mouth of the fjord, these estimates are currently already 45.5% and 43.8% of the time for communication and echolocation functions respectively, because of high ferry traffic. They could respectively increase to 50.8% and 46.0% of the time. However, these estimates do not take into account excursion boat, yacht and other boat traffic. In the lower estuary, where there is less marine traffic than in the mouth of the fjord but where there is 13 times more traffic than in the upper Saguenay, estimated figures would increase from 28.8% to 44.1% for potential hindrance to communication and 16.0% to 18.2% for echolocation. WSP's estimates of the percentage of noise exposure time are based on different measurements and assumptions than those in this advisory report (WSP 2017b). They differ slightly but are generally consistent with the estimates in this advisory report.

The risk level for individuals is therefore not nil. To determine whether the risk is high or low, we would have to know the likelihood of a behavioural response to various levels of vessel traffic and noise, as well as how severely the behavioural response affects the Beluga Whale's ability to perform its routine activities effectively. With respect to current conditions, the analysis showed that individuals in the fjord upstream of the mouth area are at higher risk of a negative impact.

(b) And if applicable, will it jeopardize the survival or recovery of the Beluga Whale population?

To assess the risk of jeopardizing the survival or recovery of the Beluga Whale population, its precarious status and current Endangered status must be taken into account. Any additional stress is likely to hinder its recovery and survival. According to multi-year data from the Saguenay-St. Lawrence Marine Park, the additional traffic will affect part of the critical Beluga Whale habitat, which is used by females and juveniles on a regular basis up to nearly 80% of the days in summer.

Based on the size of the pods reported previously, the percentage of the population found throughout the fjord at any given time was on average 2.2% and, at most, twice that at 4.4%. These are static estimates of the percentage of the population in these areas, because movements of individuals between the Saguenay and the estuary have been documented (Lemieux Lefebvre et al. 2012). As a result, it is safer to assume that more than 2% or 4% of the population could be affected by an increase in traffic in the Saguenay. However, because each individual does not spend all its time in the Saguenay area, the percentage of time each individual would be affected versus an individual spending 100% of its time in the Saguenay would decrease. To determine each individual's noise exposure level and estimate its likely effects, their use of other quieter areas must be taken into account.

Based on data on other Beluga Whale populations, it is likely that the Beluga Whales observed in the fjord originate from a particular subset of the population and that not all SLE Beluga Whales use that area. Site fidelity is a common behaviour among cetaceans. This behaviour has also been documented for the Beluga Whale (Caron and Smith 1990, Colbeck et al. 2013). It is also likely that the additional pressure related to increased traffic would be exerted on the same segment of the population. Therefore, the risk of a negative impact would theoretically remain unchanged for the portion of the population using areas not affected by the proposed

projects. The risk would increase for segments of the population using areas affected by the project. In the event that the affected area were to be temporarily or permanently abandoned, other segments of the population would be negatively affected because the displaced individuals would create additional competitive pressure on favourable habitats.

Assuming the presence of a static population in the fjord, the risk that the population will be affected is calculated by multiplying the percentage of the population using the Saguenay or its mouth, by the percentage of the time where individuals are affected by noise (Tables 1 and 2, values in parentheses). The increase in the risk to the population as a result of increased traffic at the mouth, assuming a static population (whose movements are zero), is less than 0.02% for both the communication and the echolocation functions (Table 2). This increase is higher in the upstream area of the Saguenay but does not exceed 0.09% (Table 1).

These estimates suggest that the increased risk from increased traffic, although not negligible for communication and echolocation for individuals using the Saguenay, is low for the SLE population as a whole because on average, a small percentage of the population is located in the fjord at any given time versus the rest of its habitat. However, we need to consider that this risk is in addition to existing risks, which are probably involved in the current decline (and non-recovery) of this population, which is under multiple environmental pressures, including exposure to varying levels of noise depending on the area.

The population's long-term recovery objective is 7,070 individuals, seven times more than the current population. This goal will not be achieved without expanding the currently occupied habitat and recolonizing formerly used adjacent areas. The Saguenay Fjord is one of these areas. Increasing anthropogenic pressure in this part of the habitat may further jeopardize the population's recovery.

(c) If applicable, specify which function of the life cycle will be affected, how it will be affected and during which period of the year. Please indicate whether any areas are at greater risk.

As previously explained, the Beluga Whale uses the fjord most extensively from June to October. The number of individuals in the fjord in October and November appears to be decreasing. There is a lack of information on the winter and spring period. In the context of global warming and the decrease in the ice cover period (Galbraith et al. 2017), it is likely that the Beluga Whale could change its annual winter migration to the lower estuary and the Gulf and spend more time in the Fjord.

Question 2. No mitigation measures that could be implemented by the proponent were presented in the impact study, apart from this proponent's participation in the Working Group on Marine Traffic and Protection of Marine Mammals in the Gulf of St. Lawrence committee (G2T3M) of the St. Lawrence Action Plan's Navigation Coordination Committee. Please indicate, where applicable, the mitigation measures that would avoid:

(a) Jeopardizing the survival or recovery of the Beluga Whale population

Although other risks associated with traffic are not zero, the Beluga Whale is primarily affected by the noise radiated by ships in their environment. Any action to reduce the level and duration of this noise in the Beluga Whale's environment will reduce the risk of harm. A list of possible actions is provided in a DFO Action Plan developed for this purpose (DFO 2018). Others have recently been reviewed by an Expert Committee on Southern Resident Killer Whales in the Strait of Georgia (DFO 2017a). These potential actions, which address noise reduction at source or the spatial and temporal modification of noise distribution in the environment and its overlap with animals, are not repeated here.

The most effective measures obviously involve locating the new marine terminals outside Beluga Whale habitat. This would help eliminate the need to consider additional stressors in the cumulative anthropogenic effects on this population and its recovery.

The proponent mentioned the possibility of using Rio Tinto vessels to ship Arianne Phosphate's apatite concentrate to international markets (WSP 2017a, p. 229). Assuming that all the apatite concentrate were to be transported by ships (240 transits/year) supplying Rio Tinto with bauxite and alumina, the increased risk to the Beluga Whale arising from marine transportation associated with the marine Terminal project on the north shore of the Saguenay would be nil (WSP 2017b). However, this would only reduce part of the total increase in expected traffic from other projects and their effects (see Table 1).

Commissioning new ferries to eliminate the need for a third ferry during the peak summer season (WSP 2017a, p. 228-229) has the advantage of reducing the time Beluga Whales are exposed to ferry noise at the mouth of the fjord. Because this is the major source of traffic in the mouth of the Saguenay (Gervaise et al. 2012), this gain in the peak summer months should be significant.

Mitigation measures restricting spatial and temporal use could take advantage of changes in Beluga Whale use of the fjord, depending on the season, time of day and tidal phase in the highest-use areas. Limiting traffic when larger numbers of individuals are likely to be in the area would limit the risk of harm. Additional information on nocturnal use and periods when there are no Beluga Whales in the area may allow additional time windows. Technologies for monitoring areas of interest used by the Beluga Whale and informing mariners in real time could be examined.

In all the cases described above, a long-term follow-up would be required to assess and monitor the effects of the proposed measures. The Saguenay-St. Lawrence Marine Park's multi-year series of summer observations can provide a basis for comparison. The series should be continued to provide indicators of fluctuations and trends in the Beluga Whale's use of the fjord.

The effects of increased traffic in part of the St. Lawrence Beluga Whale habitat must be examined, taking into account the cumulative effects of all other potentially harmful anthropogenic pressures.

(b) Harming belugas (individuals).

See (a) above.

(c) Please indicate the extent to which these mitigation measures would reduce the level of risk in (a) and (b) (define the risk level as "none," "low," or "high").

The most effective mitigation measures are avoidance. In the case where there is no overlap between traffic generated by the proposed projects and the Beluga Whale, the risk of effects would become nil. Except for the option of using Rio Tinto ships to transport the apatite concentrate from the Terminal project on the north shore of the Saguenay, it is very unlikely, if not impossible, that there will be no overlap. Studies have measured the effect of increased noise levels on the Beluga Whale's acoustic space (e.g. Gervaise et al. 2012). However, we are currently unable to quantify the magnitude of the effects of a reduction in acoustic space on the vital activities of the Beluga Whale (or other marine mammals) and its survival. This population is already in decline and under multiple anthropogenic and natural pressures. The proposed projects will increase traffic in part of the currently quiet critical habitat, and the consequences of this, regardless of mitigation measures (except for the total absence of overlap), will expose the Beluga Whale to increased noise levels. Elevated risks cannot be ruled out given the current

state of the declining population for which noise has been identified as a risk factor (Williams et al. 2017; DFO 2014).

Question 3. Are other marine mammal species in the Saguenay Fjord and the St. Lawrence Estuary (SLE) likely to be affected by the increase in marine traffic caused by the project(s)?

(a) If so, which species?

The Minke Whale is the other whale species most commonly found in the fjord, especially at the mouth, but also in the downstream portion of the fjord (Conversano 2013). Harbour Seals also use the fjord on a regular basis (Robillard et al. 2005). Other species are only reported occasionally.

However, the lower estuary is used by more than a dozen species of marine mammals (Lesage et al. 2007) that are likely to be affected by increased traffic, including other species at risk, such as the Blue Whale, the Fin Whale, Harbour Porpoise and occasionally the Right Whale. The Grey Seal is present in summer and the Harp Seal in winter.

The risk of collision associated with this increase in the number of transits by large ships is considered low for the Harbour Porpoise and the Atlantic White-sided Dolphin. However, there is a real risk of injury or fatal collision for large whales that inhabit the SLE (Fin Whale, Blue Whale, Humpback Whale, and Minke Whale).

(b) Do the Beluga Whale risk assessments and mitigation measures apply to those species? If not, what would the effects and appropriate mitigation measures be?

Yes, the potential risks and mitigation measures mentioned above partially apply to these species. However, echolocation is a function that has not been observed in baleen whales, who, contrary to the Beluga Whale, communicate in the low-frequency band (< ~ 5 kHz) (Au and Hastings 2008) where shipping underwater noise is concentrated. In addition, the Lower Estuary and Gulf of St. Lawrence are larger basins than the Saguenay Fjord, and low-frequency shipping noise can travel over 100 km (cf. Aulanier et al. 2016b). Current St. Lawrence marine traffic noise levels will escalate as traffic increases. The escalation factor could reach 1.14 by 2030 (F factor, Table 3). In addition, increased marine traffic will raise the risk of collision with large whales.

Conclusion

There is global concern over the effects of maritime traffic because the chronic noise that it generates travels great distances. It is considered a form of habitat degradation, rather than stressor, that triggers behavioural responses that increase in severity with the level of exposure. The Beluga Whale and other cetaceans are highly acoustic animals, and the effects of marine traffic shrink the time and space of their world, which is known as their acoustic space. Reducing this space can result in lost opportunities, including the ability to feed or to feed effectively, to detect or communicate with congeners or to detect danger. Occasional interference with these vital functions is not likely to have long-term effects on reproduction or survival. However, repetition of these lost opportunities over several days or during critical periods of the annual cycle can lead to measurable impacts on vital parameters. This has been demonstrated in particular in some populations of dolphins and beaked whales repeatedly exposed to marine observation activities or acoustic tests (Lusseau and Bejder 2007).

The SLE Beluga Whale is chronically exposed to the noise of merchant ships that make about 6,000 transits per year. In addition, five ferry lines that operate in various areas of the Beluga Whale's summer habitat make tens of thousands of transits (cf. Simard et al. 2014), and marine mammal observation vessels and boaters who operate in the area also account for several

hundred daily transits. Although an overall picture of noise in the Beluga Whale habitat is not currently available, noise levels have been characterized in some areas (Simard et al. 2010a, McQuinn et al. 2011, Gervaise et al. 2012, Simard and Roy 2013, Roy and Simard 2015, Aulanier et al. 2016b). These studies indicate that Beluga Whale habitat is heterogeneous in terms of ambient noise levels. It includes areas such as the Saguenay Fjord and habitats south of the central islands of the estuary, which are not exposed to much shipping noise, and other habitats such as shipping lanes in the Laurentian Channel in the lower estuary and the north channel in the upper estuary and the mouth of the Saguenay, which are chronically highly ensonified. The effect of chronic shipping noise on the Beluga Whale's acoustic space was measured at the mouth of the Saguenay where communication space was reduced to 30% of its area without ships half the time and 15% of its area without ships one quarter of the time (Gervaise et al. 2012). Although a quantitative analysis of the likely effects of this reduction in the Beluga Whale's acoustic space could not be completed as part of this Science Advisory Report, it is difficult to assume that such a sustained level of traffic would not result in lost opportunities for the Beluga Whale. In addition, conservation of quiet high-density habitats provides animals with spatial and temporal windows to perform their activities effectively (Williams et al. 2015). Habitats along the south shore and Saguenay are currently not very noisy given the low level of marine traffic in these areas.

The two Saguenay harbour projects will triple current traffic in the Saguenay from 450 to almost 1,300 transits per year, which will also add about 1,000 transits to the 6,000 current merchant ship transits in the SLE. These two projects alone will produce a 10% increase in total shipping traffic in the SLE and the Beluga Whale's habitat. This significant increase in traffic will increase the level of ambient noise and reduce the temporal and spatial windows of opportunity for the Beluga Whale in the Saguenay, its mouth and in the lower estuary. The risk of collisions with large whales, including species at risk (Right Whale, Blue Whale and Fin Whale), will also increase. In this Science Advisory Report, we determined that these increases in traffic are likely to interfere with Beluga Whale communication and echolocation by producing a 2 to 5% increase in the time during which vital functions could be affected. In some areas, such as the mouth of the Saguenay or the northern channel of the estuary, this increase is in addition to the noise generated by the current high volume of traffic which may already affect Beluga Whale communication or echolocation 39% to 46% of the time.

The SLE Beluga Recovery Plan included a number of measures to reduce noise in Beluga Whale habitat (DFO 2012). A review of this plan and its effectiveness found that the proposed measures failed to meet this objective (DFO 2017b). The proposed projects will not help achieve this goal. Conversely, more frequent ensonification of an area that is currently relatively quiet (the Saguenay) and the 10% increase in traffic in the lower estuary will hinder recovery objectives and measures recently proposed to minimize the effects of the noise stressor. Although the effect of these projects on population trajectory cannot be estimated in the context of this Science Response, it is highly unlikely that they will benefit individuals or promote population recovery.

In a context of finding underwater noise management solutions in the SLE, the potential for overall noise reduction or at least ensuring that there is no net gain in noise from this project could be examined in two or three ways. First, the proponent's suggestion that Rio Tinto ships be used to transport apatite concentrate would eliminate the shipping noise that the project would otherwise introduce. Secondly, noise generated by major sources currently in operation could be reduced in order to allow new sources to be introduced. Gains at the mouth of the Saguenay, for example, could help offset losses in the Saguenay caused by increased traffic, since the increase in traffic will probably affect the same segment of the Beluga Whale population. Thirdly, noise abatement measures to reduce the acoustic footprint of these two

projects could also be examined. For example, should alternative and land export routes be considered in order to avoid exporting resources from the apatite mine via the Saguenay Fjord? For unavoidable transits through the Saguenay, various vessel design measures (vessel renovation or construction engineering), noise reduction at source initiatives or an increase in the number of silent windows for the Beluga Whale should be examined.

This Science Advisory Report provides calculations to estimate the time during which Beluga Whale communication and echolocation functions anywhere in the study area could be disrupted by increased transits in the SLE and the Saguenay Fjord. However, a comprehensive assessment of the impacts of additional traffic on the Beluga Whale population or individuals requires a cumulative analysis of noise exposure that takes into account individual movements and use of the various areas. The number of individuals whose physical condition could be adversely affected as a result of lost opportunities could be used to estimate the likely effect on reproduction and survival rates, as well as population trajectory (taking into account the gender and number of affected individuals). This information was not available when this Science Advisory Report was produced.

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